Highlights of Vanderbilt's Presence in PHENIX

Charles F. Maguire
Vanderbilt University

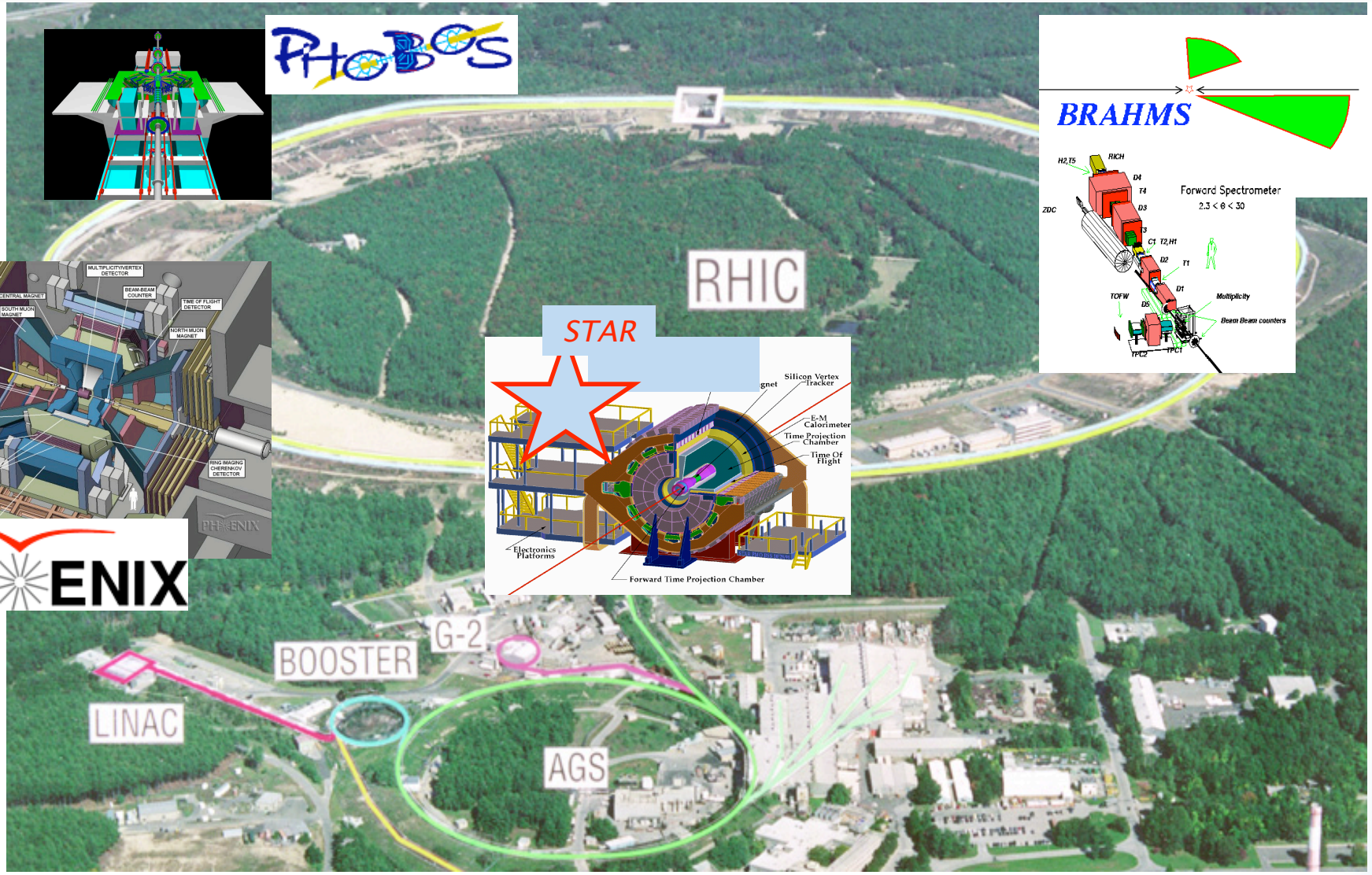
Who We Are and Will Be

- **Ms. Martha Holmes**
  - New graduate student, joins as an RA for the Summer ’03
  - Two years as a Peace Corps volunteer in Burkina Faso, West Africa
- **Mr. Hugo Valle**
  - New graduate student, joins as a full time RA in June ’03
  - Two summers as an REU student at VU working in PHENIX
- **Dr. Dipali Pal**
  - New research associate, joins in June ’03, formerly at WIS
  - Extensive experience working on the □ analysis, especially for simulation corrections
- **Dr. Debsankar Mukhopadhyay**
  - New research associate, joins in June ’03, formerly at WIS
  - Extensive experience working on the □ analysis, especially for hardware systematics
- **Dr. Indrani Ojha**
  - Research associate specializing in simulation software development and production
  - Critical skills in database applications (Objectivity, file catalog), remote site support
- **(future) Assistant Prof. Julia Velkovska**
  - Will join the group in August ’03
  - Dr. Momchil Velkovsky will also join as a half-time research associate for one year
- **Associate Prof. Vicki Greene**
  - Pad Chamber subsystem manager
- **Old Prof. Charlie Maguire**
  - Simulation subsystem manager

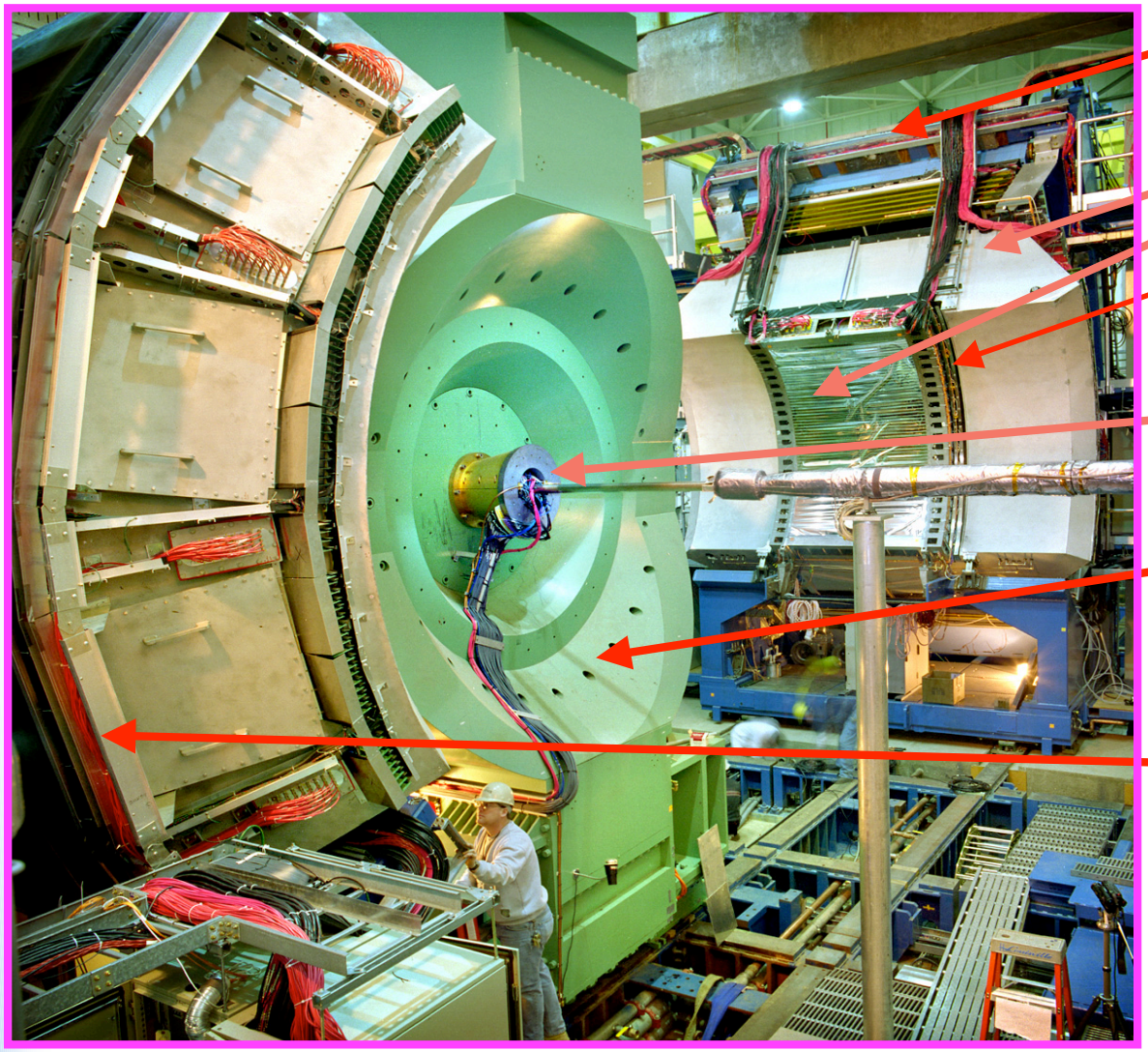
What We Do in PHENIX

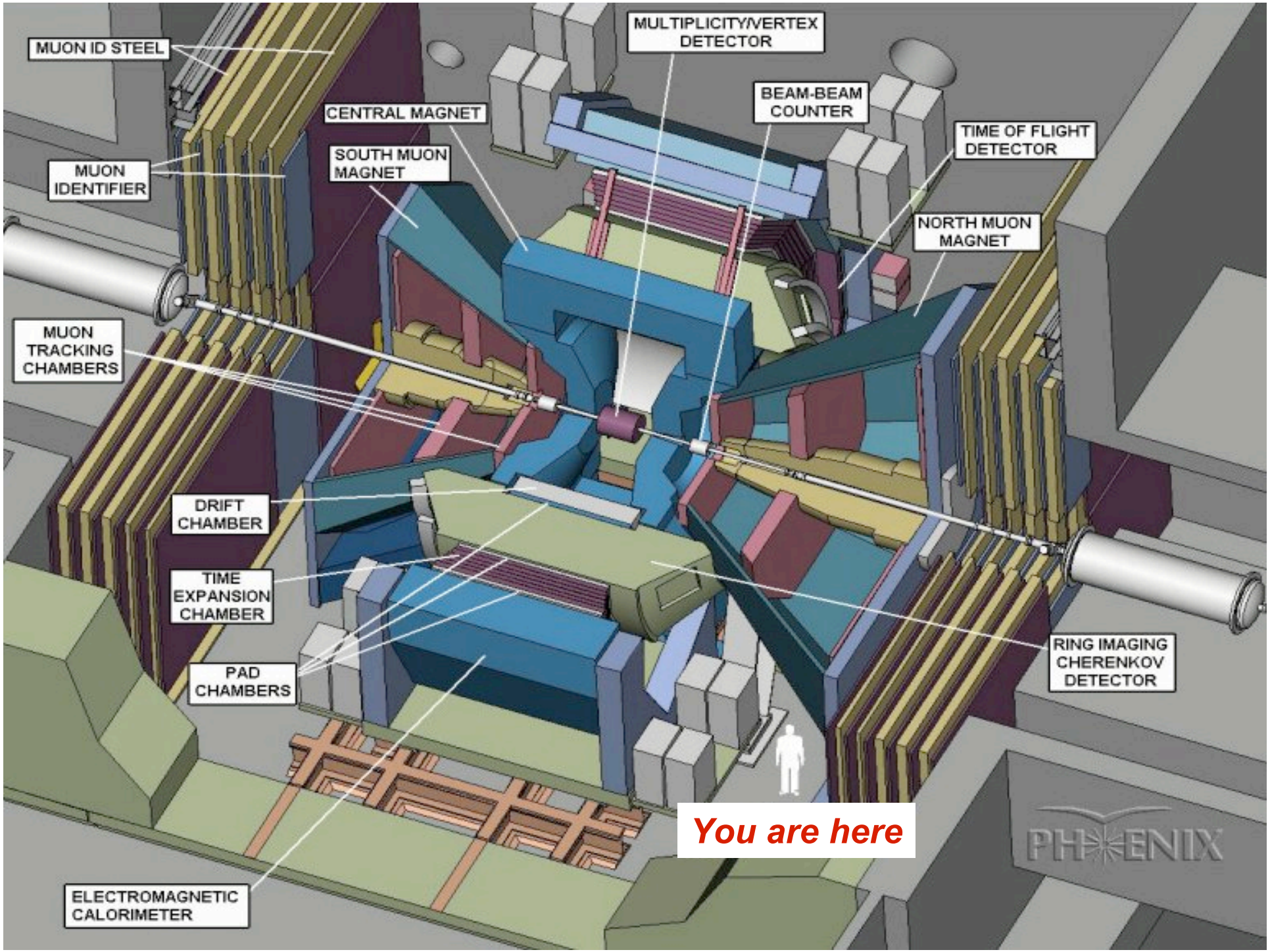
- **PHENIX Service**
  - Pad Chamber (PC) Detector Subsystem
    - Important component of PHENIX Central Arm charged particle tracking system Only three space point device without which tracking would be hopeless
    - A troubled construction beginning but an extraordinarily successful completion
    - Concerted effort of several institutions (BNL, WIS, Lund, ORNL, and Vanderbilt)
    - Important Vanderbilt contribution VCHIPP for building PC2 and PC3 here
  - Simulation Software
    - Crucial element for the design and optimization of the original PHENIX hardware
    - Standard analysis tool for evaluating the actual performance of the hardware
- **PHENIX Physics**
  - Paper Preparation Groups
    - 001 Particle Multiplicity (First PHENIX publication, Run1 Au+Au at 130 GeV)
    - 016 Phi meson decay to K^+K^- (Run 2 Au+Au at 200 GeV)
    - 019 Multiplicity and transverse energy (Run2 Au+Au at 200 GeV)
  - Internal Review Committees
    - 001 Particle Multiplicity (Vicki Greene chair, first paper relied heavily on PCs)
    - 017 J/Psi (Run2 p+p at 200 GeV)

The Four RHIC Experiments



PHENIX Central Spectrometers




MUON ID STEEL
MULTIPLICITY/VERTEX DETECTOR
BEAM-BEAM COUNTER
CENTRAL MAGNET
TIME OF FLIGHT DETECTOR
SOUTH MUON MAGNET
MUON IDENTIFIER
NORTH MUON MAGNET
MUON TRACKING CHAMBERS
DRIFT CHAMBER
TIME EXPANSION CHAMBER
RING IMAGING CHERENKOV DETECTOR
PAD CHAMBERS
You are here
ELECTROMAGNETIC CALORIMETER
PHENIX

Current Physics Topic for VU Group

$\phi \rightarrow K^+K^-$

- Motivation for the study of the ϕ at RHIC
- Description of PHENIX particle identification system
- Simulations of the ϕ pair mass resolution
- Signal spectra observed in PHENIX
- Summary of preliminary results

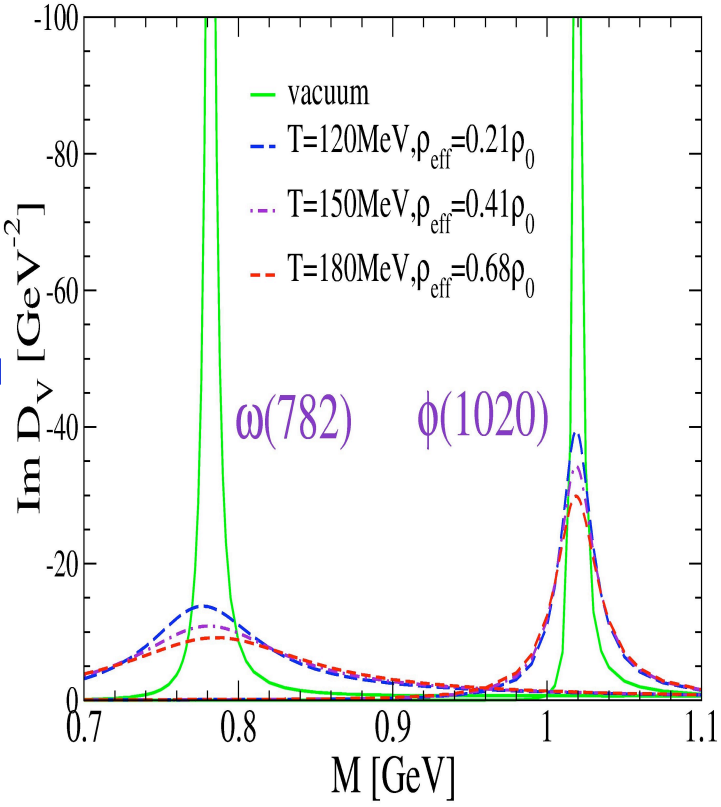
What is the □ Meson?

- m ~ 1019 MeV/c^2
  slightly heavier than a proton
  a little more than two Kaons (494 MeV/c^2)
- Intrinsic width □ ~ 4.23 MeV/c^2
- c□ ~ 44 fm
- quark content : s + anti-s
  where s is the “strange” quark
  (protons and neutrons are composed of
  3 up and down quarks, uud and udd)
- Decay modes:
  □□ $K^+ K^-$ (49.2%)
  □□ $e^+ e^-$ (0.03%)

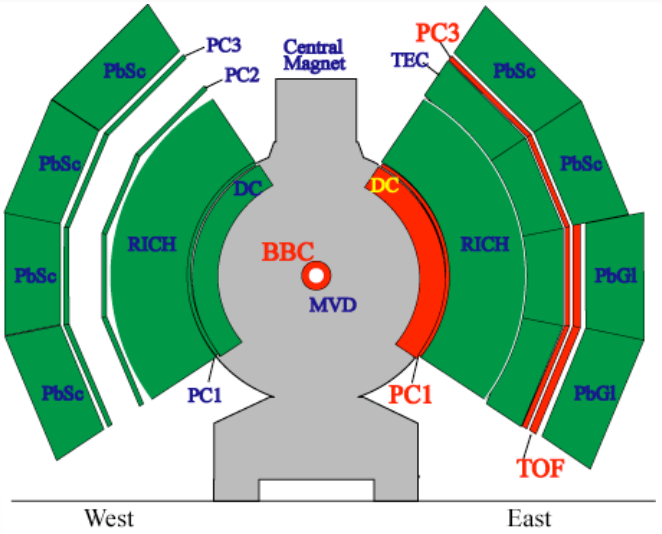
The Interest in the □(1020)

- Restoration of approximate chiral symmetry may modify the □ mass and width in medium
  - Mass = 1019.456 +/- 0.020 MeV (PDG 2002) Breit-Wigner □ = 4.26 +/- 0.05 MeV
  - Look for variations with centrality
  - Compare to p+p and d+A results
- These modifications may result in a change in the branching fraction of □□ K^+K^- and □□ e^+e^- when the □ decays in medium ($t_{□}$ ~ 44 fm/c)
  - Compare different pair p_T ranges
- Final state interactions of kaons may lower the apparent measured branching fraction of □□ K^+K^- relative to □□ e^+e^-
  - Measure both channels in the same detector

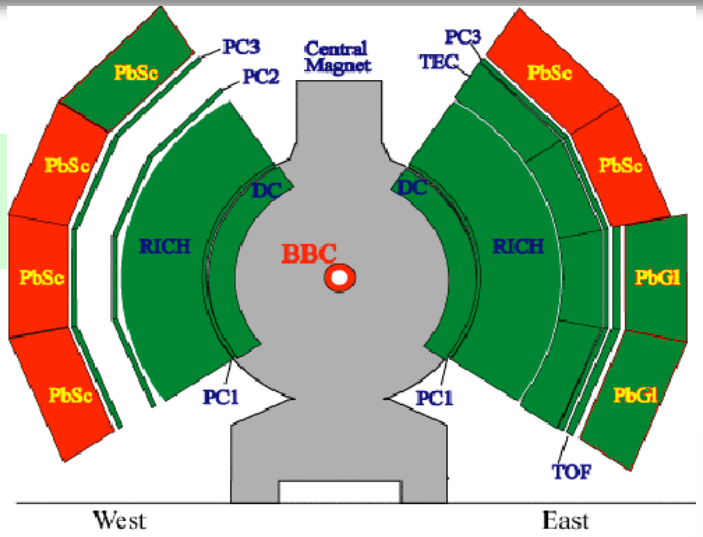
R. Rapp nucl-th/0204003



Detecting □±, K±, p± in PHENIX



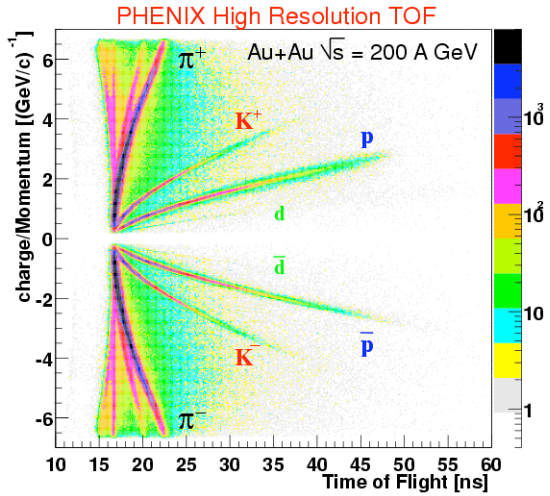
momentum resolution
$\delta_p/p \sim 1\% \oplus 1\%\ p$



Inclusive identified hadron spectra use TOF in East Arm

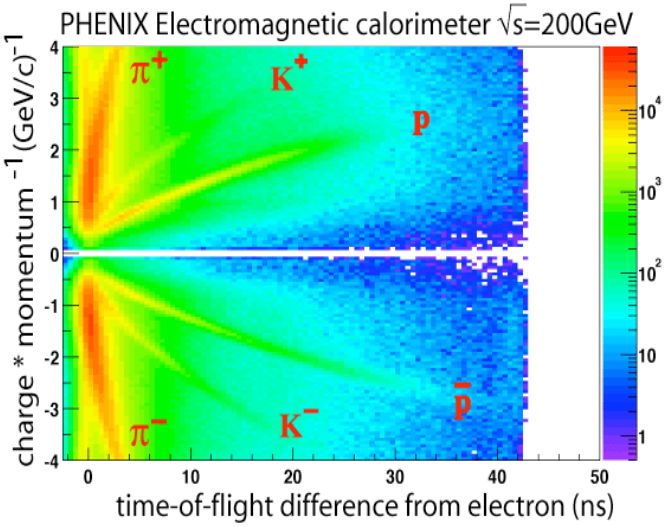
TOF resolution **120 ps**

EMCal resolution 450 ps

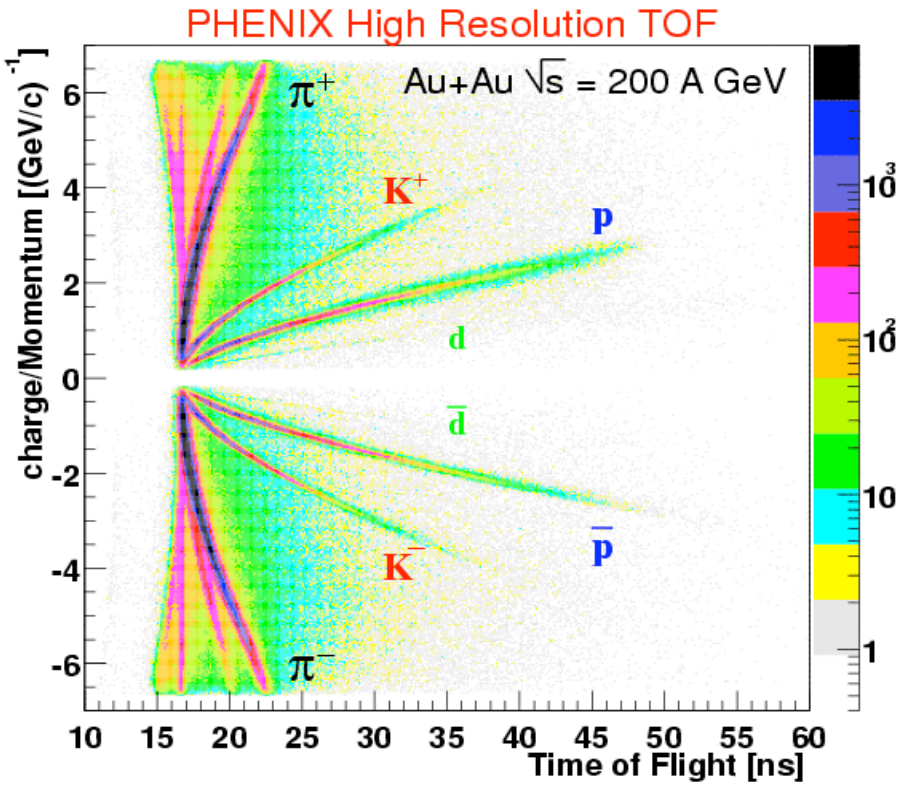


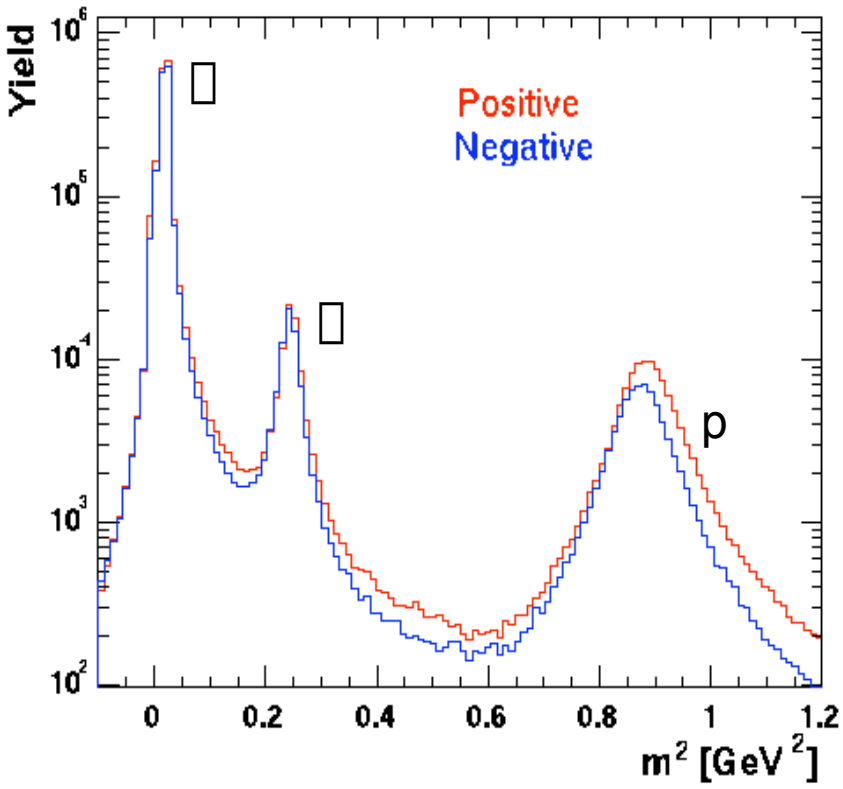
□->K^+K^- uses TOF-TOF, EMCal-EMCal, and TOF-EMCal in East

□->e^+e^- uses RICH, EMCal-EMCal in East-West, East-East, and West-West



Particle Identification in High Resolution TOF

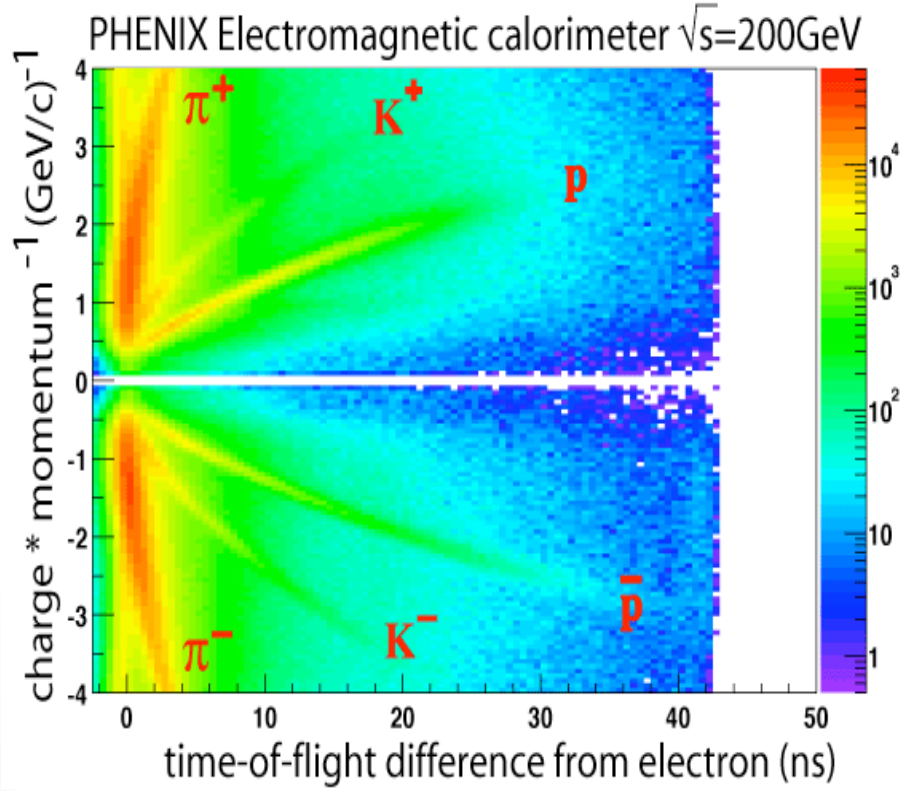


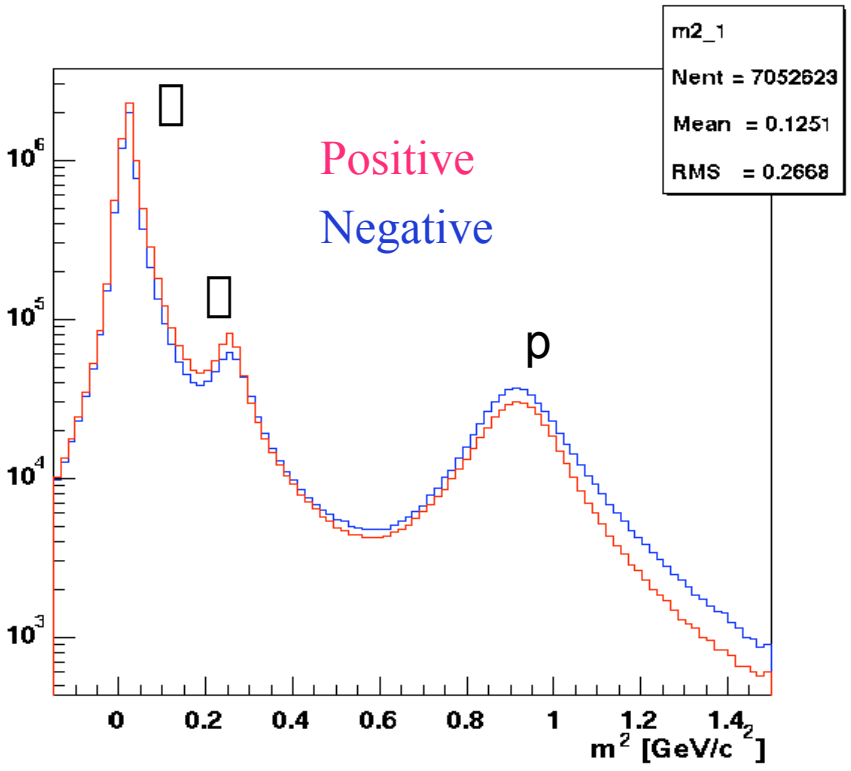


TOF timing resolution: $\sigma_t \sim 120$ ps

K/π separation up to 2.0 GeV/c

EMCal Particle Identification

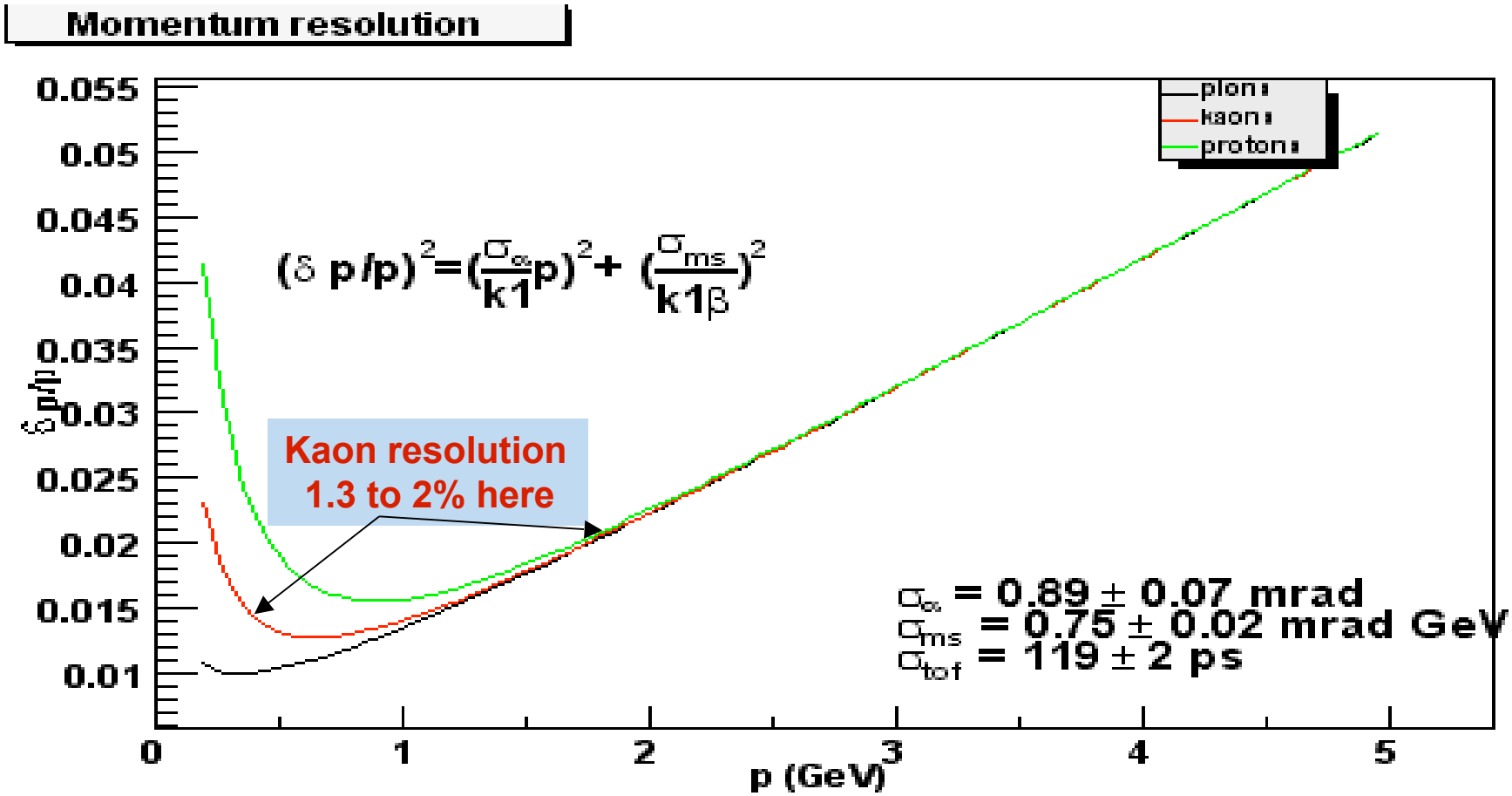




EMCAL resolution: $\sigma_t \sim 450$ ps

K/π well separated for 0.3 < p [GeV/c] < 1.0

Single Particle Momentum Resolution in PHENIX From Studies of the Masses of the Identified Hadrons



Pair Mass Resolution Simulation

- **Fast Monte Carlo Software**
  - Generate single □ meson events thrown into the complete PHENIX East Arm acceptance
  - Decay Kaon momenta are randomized in momentum magnitude
  - Randomization □ taken from studies of single particle mass resolution studies of identified hadrons
  - Pairs are reconstructed with altered Kaon momenta
- **Algorithm**

$M^2 = (E_1 + E_2)^2 - p_1^2 - p_2^2 - 2p_1 * p_2 * \cos(\square_{12})$

$E^2 = m_K^2 + p^2$

Randomize each momentum magnitude p according to:

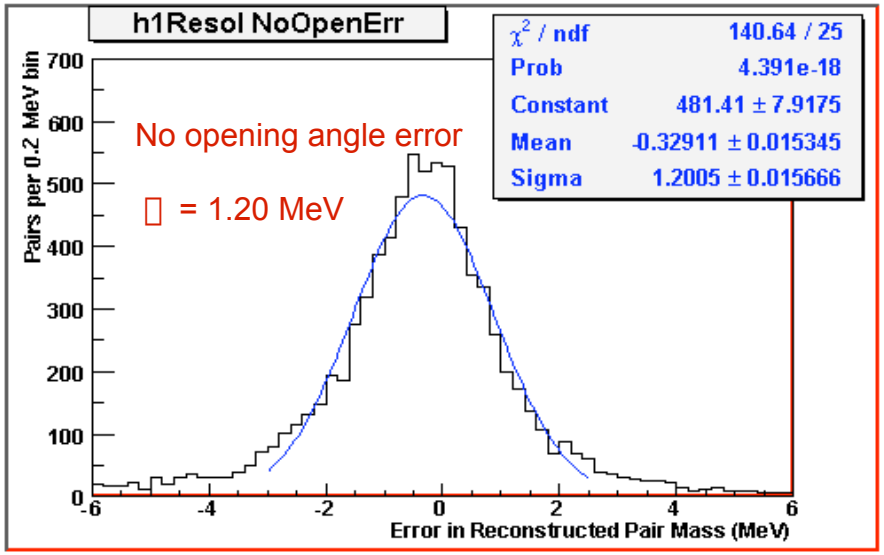
Drift Chamber resolution parameter $\square_{\square}$ from identified mass study

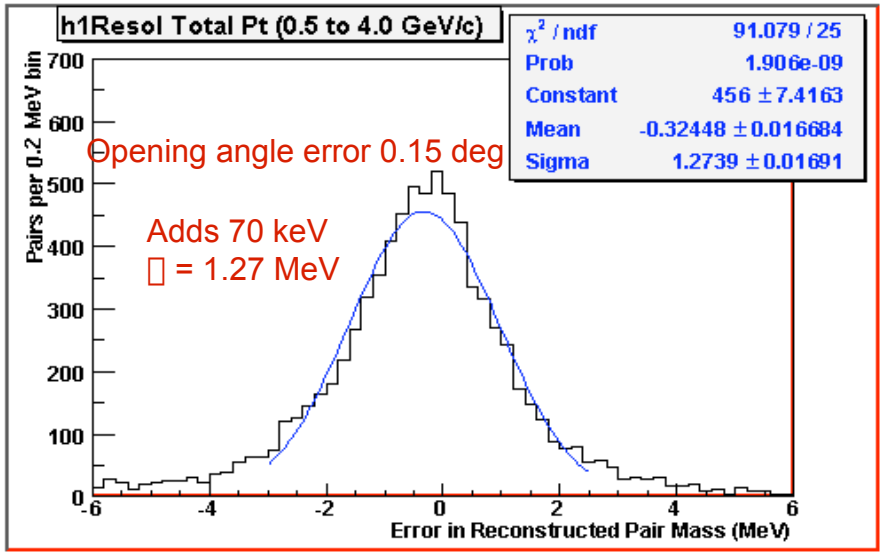
Multiple scattering parameter $\square_{MS}$ from identified mass study

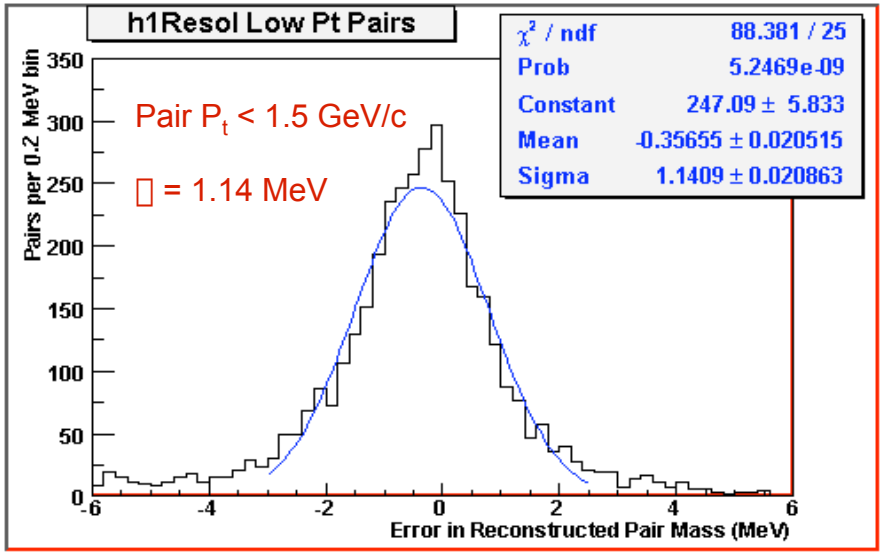
Pair opening angle $\square_{12}$ error taken from simulation of single kaon momentum direction errors

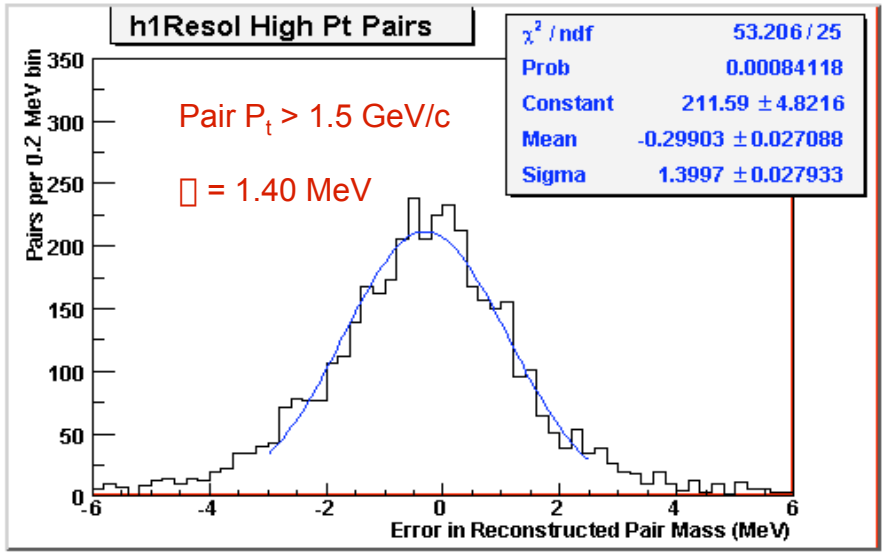
Results of Pair Mass Resolution Simulation:

PHENIX obtains excellent pair mass resolution (~1.25 MeV) for the









□ $K^+ K^-$ from TOF-TOF Pairs

Au + Au minimum bias (0-92% central) at E_{cm}=200 GeV

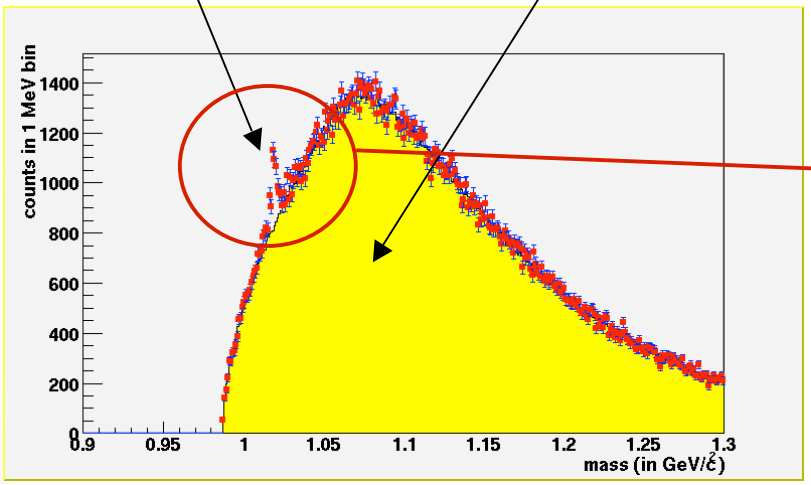
□ signal : 1410±131

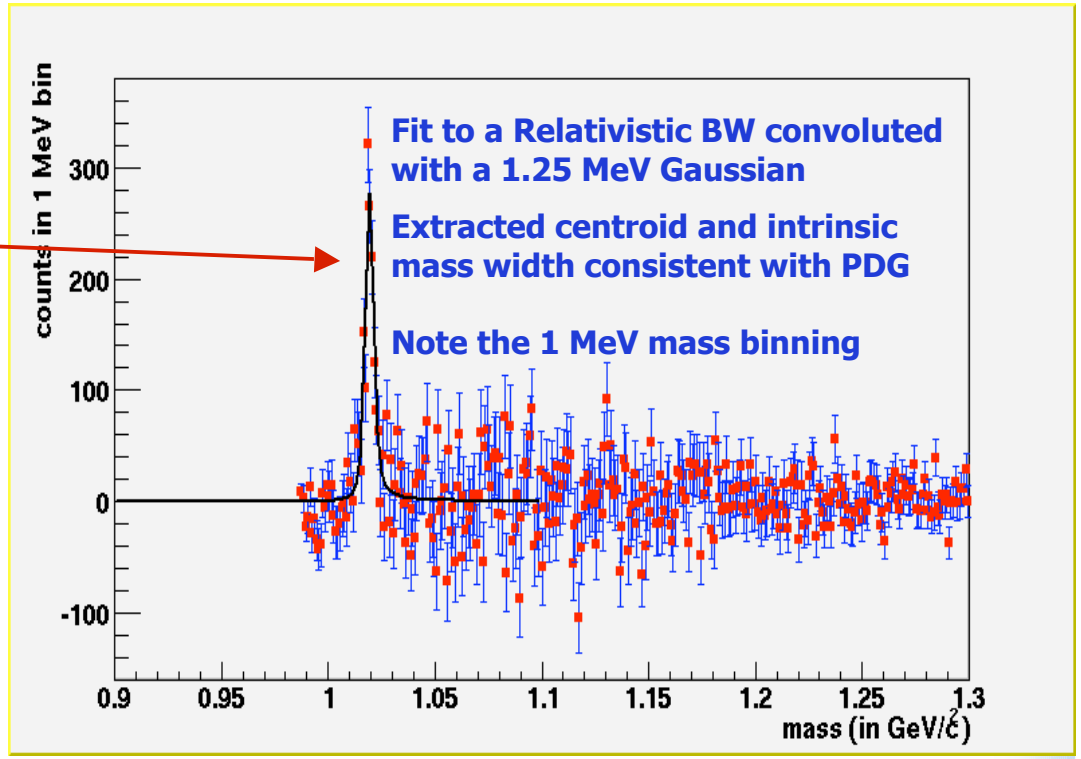
(within the window of 1.014<$m_{□}$<1.024 GeV)

S/B = 1/6

Actual Pairs

Background





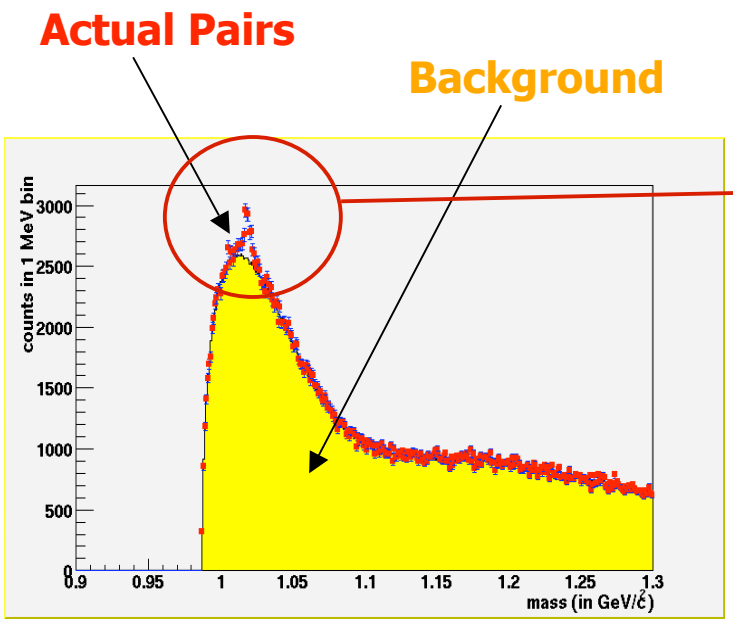
□ $K^+ K^-$ from TOF-EMCal Pairs

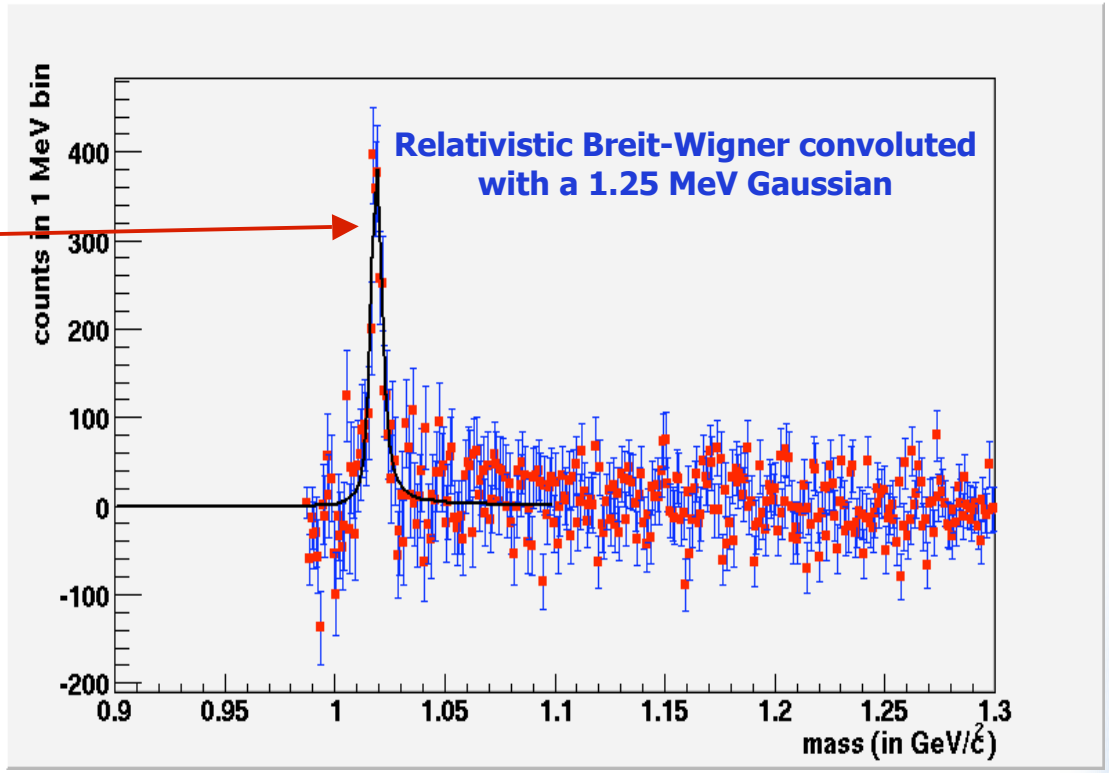
Au + Au minimum bias (0-92% central) at E_{cm}=200 GeV

□ signal : 2276±217

(within the window of 1.014<$m_{□}$<1.024)

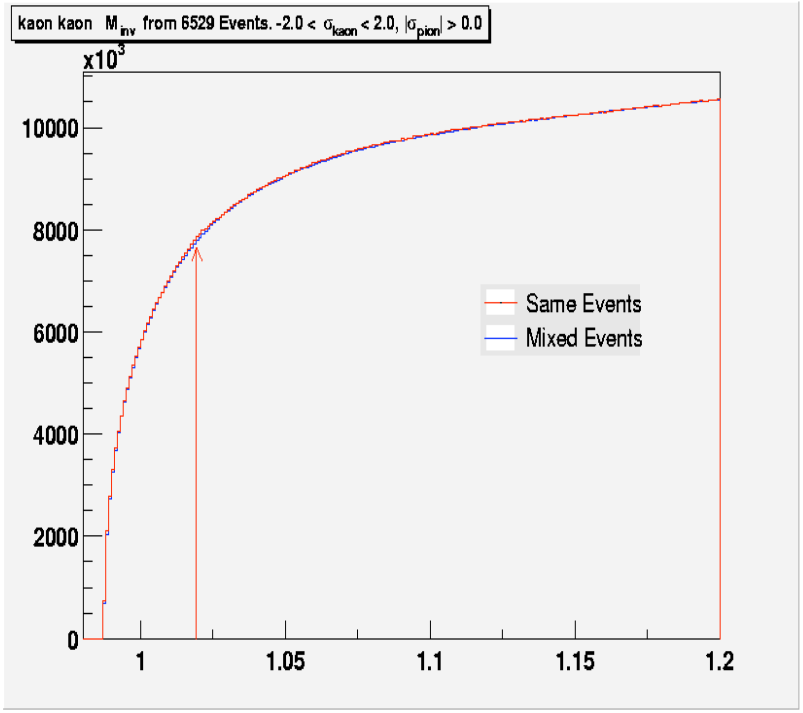
S/B = 1/11

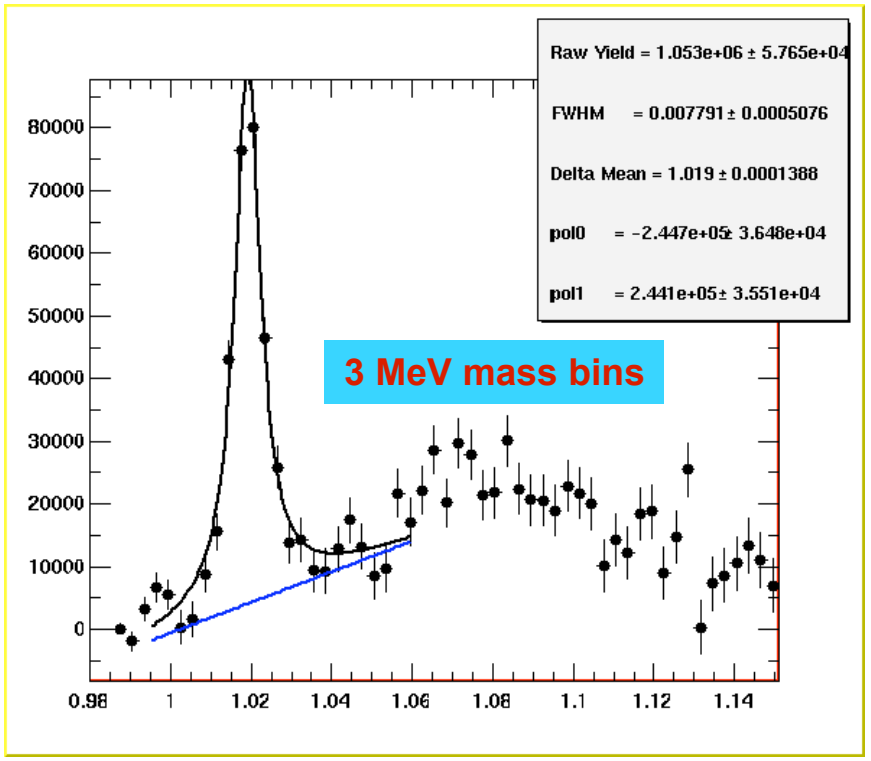




STAR

K^+K^- pair invariant mass
As seen by our competitors at RHIC





background subtracted

Au + Au collisions
Mearsured Mass=1019 MeV/c^2, FWHM=7.8±0.5 MeV/c^2

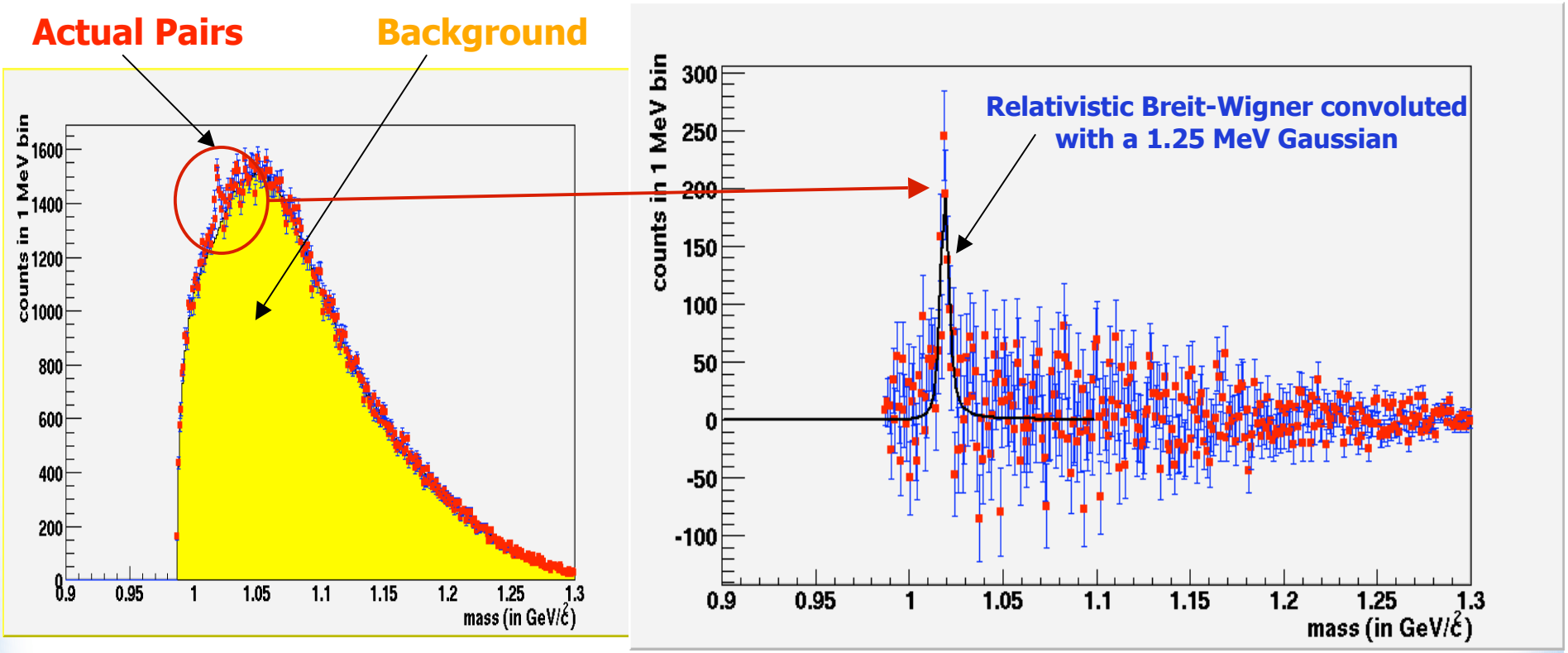
□ $K^+ K^-$ from EMCal–EMCal Pairs

Au + Au minimum bias (0-92% central) at E_{cm}=200 GeV

□ signal : 1095±118

(within the window of $1.014<m_{□}<1.024$)

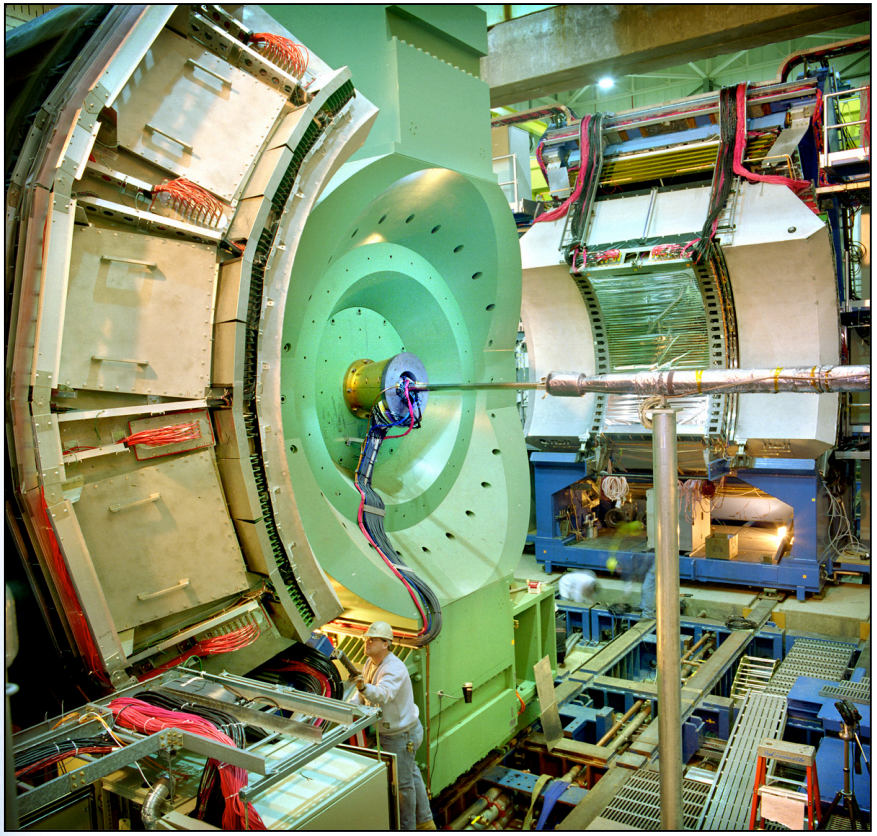
S/B = 1/12

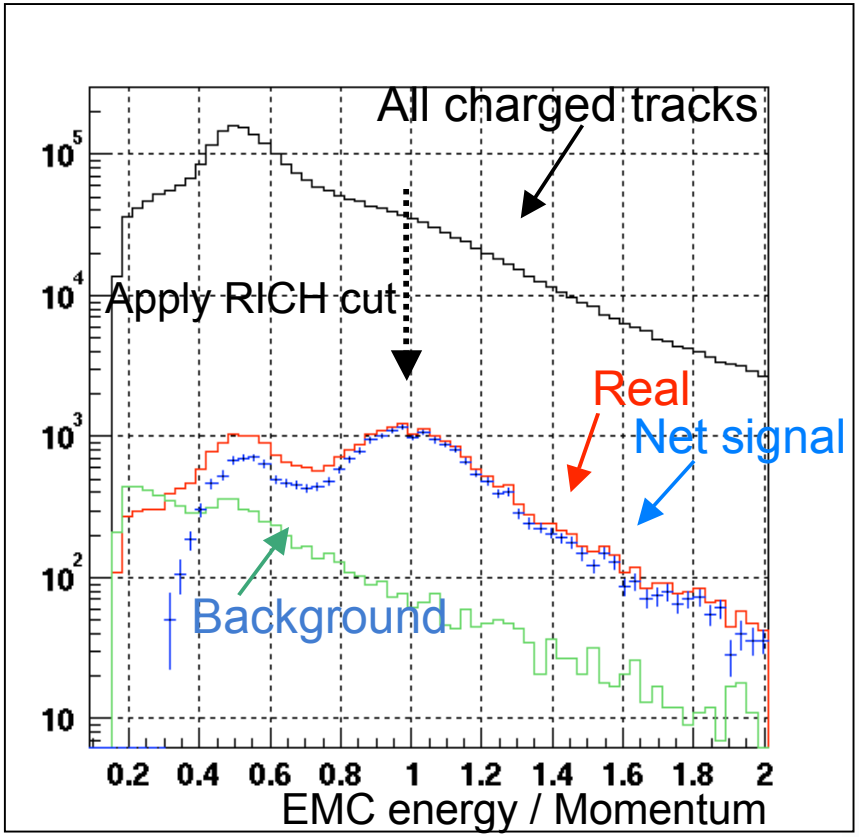


Electron Identification for □ -> e^+e^-

PHENIX has excellent electron identification capabilities.

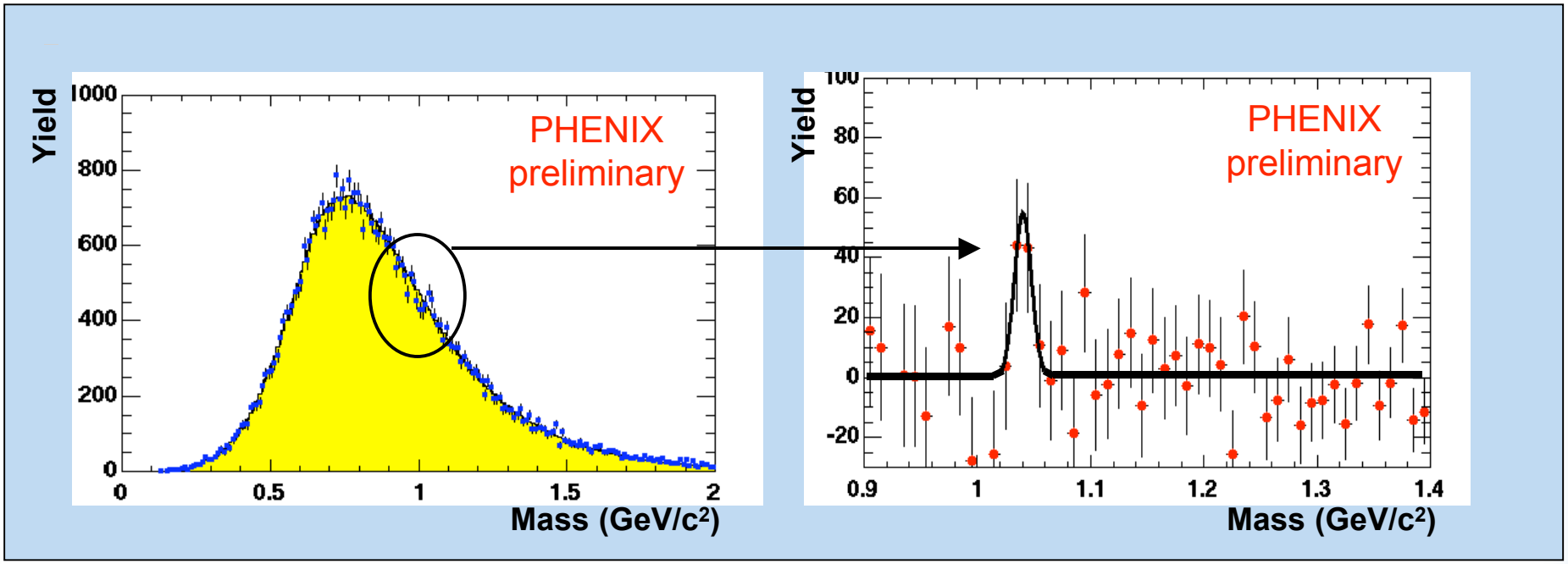
- Ring Imaging Cerenkov Counter - threshold selection
- Time Expansion Chamber - dE/dx measurement
- Electromagnetic Calorimeter - Energy-Momentum match





$\phi \rightarrow e^+e^-$

Au + Au minimum bias (0-90% central) at E_{cm}=200 GeV



$$\text{Signal} = 101 \pm 47\,(\text{stat})^{+56}_{-20}\,(\text{sys})$$

Signal / Background = 1 / 20

Mass peak and width agree within errors of PDG values.

Summary

Au + Au minimum bias (0-90% central) at E_{cm}=200 GeV

dN/dy corrected for vacuum PDG branching fraction values.

B.F. $\phi \rightarrow e^+e^-$ = 2.9 x 10^{-4}, B.F. $\phi \rightarrow K^+K^-$ = 0.49

PHENIX Preliminary

$$\phi \rightarrow e^+e^-: \quad \frac{dN}{dy} = 5.4 \pm 2.5(stat)^{+3.4}_{-2.8}(sys)$$

PHENIX Preliminary

$$\phi \rightarrow K^+K^-: \quad \frac{dN}{dy} = 2.01 \pm 0.22(stat)^{+1.01}_{-0.52}(sys)$$

Data are consistent with the free vacuum PDG branching fraction values to within 1σ statistical errors.

New ϕ -> K^+K^- data being analyzed with the use of the EMCal will enable us to set better limits on the dN/dy, the mass centroid, and the width.

PHENIX

12 Countries; 57 Institutions; 460 Participants*

Brazil	University of São Paulo, São Paulo
China	Academia Sinica, Taipei, Taiwan
	China Institute of Atomic Energy, Beijing
	Peking University, Beijing
France	LPC, University de Clermont-Ferrand, Clermont-Ferrand
	Dapnia, CEA Saclay, Gif-sur-Yvette
	IPN-Orsay, Universite Paris Sud, CNRS-IN2P3, Orsay
	LLR, Ecòle Polytechnique, CNRS-IN2P3, Palaiseau
	SUBATECH, Ecòle des Mines at Nantes, Nantes
Germany	University of Münster, Münster
Hungary	Central Research Institute for Physics (KFKI), Budapest
	Debrecen University, Debrecen
	Eötvös Loránd University (ELTE), Budapest
India	Banaras Hindu University, Banaras
	Bhabha Atomic Research Centre, Bombay
Israel	Weizmann Institute, Rehovot
Japan	Center for Nuclear Study, University of Tokyo, Tokyo
	Hiroshima University, Higashi-Hiroshima
	KEK, Institute for High Energy Physics, Tsukuba
	Kyoto University, Kyoto
	Nagasaki Institute of Applied Science, Nagasaki
	RIKEN, Institute for Physical and Chemical Research, Wako
	RIKEN-BNL Research Center, Upton, NY
	University of Tokyo, Bunkyo-ku, Tokyo
	Tokyo Institute of Technology, Tokyo
	University of Tsukuba, Tsukuba
	Waseda University, Tokyo
S. Korea	Cyclotron Application Laboratory, KAERI, Seoul
	Kangnung National University, Kangnung
	Korea University, Seoul
	Myong Ji University, Yongin City
	System Electronics Laboratory, Seoul Nat. University, Seoul
	Yonsei University, Seoul
Russia	Institute of High Energy Physics, Protovino
	Joint Institute for Nuclear Research, Dubna
	Kurchatov Institute, Moscow
	PNPI, St. Petersburg Nuclear Physics Institute, St. Petersburg
	St. Petersburg State Technical University, St. Petersburg
Sweden	Lund University, Lund

USA	Abilene Christian University, Abilene, TX
	Brookhaven National Laboratory, Upton, NY
	University of California - Riverside, Riverside, CA
	University of Colorado, Boulder, CO
	Columbia University, Nevis Laboratories, Irvington, NY
	Florida State University, Tallahassee, FL
	Georgia State University, Atlanta, GA
	University of Illinois Urbana Champaign, Urbana-Champaign, IL
	Iowa State University and Ames Laboratory, Ames, IA
	Los Alamos National Laboratory, Los Alamos, NM
	Lawrence Livermore National Laboratory, Livermore, CA
	University of New Mexico, Albuquerque, NM
	New Mexico State University, Las Cruces, NM
	Dept. of Chemistry, Stony Brook Univ., Stony Brook, NY
	Dept. Phys. and Astronomy, Stony Brook Univ., Stony Brook, NY
	Oak Ridge National Laboratory, Oak Ridge, TN
	University of Tennessee, Knoxville, TN
	Vanderbilt University, Nashville, TN

*as of July 2002